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Atmospheric Measurement Techniques Discussions

Interactive comment on "Characterization of anthropogenic methane plumes with the Hyperspectral Thermal Emission Spectrometer (HyTES): a retrieval method and error analysis" *by* L. Kuai et al.

Anonymous Referee #1

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Manuscript "Characterization of anthropogenic methane plumes with the Hyperspectral Thermal Emission Spectrometer (HyTES): a retrieval method and error analysis" of Kuai et al., submitted for publication in AMT, covers an important and relatively new topic, namely airborne observations of methane plumes emitted by localized methane emission sources, appropriate for AMT. The paper is well-written and contains new material. I therefore recommend publication after the major and minor comments listed below have been carefully considered by the authors.

Major comments:

Abstract: It is written that the "Total error from single retrieval is approximately 20%". This suggests that this includes not only random errors ("precision") but also systematic errors but it is also written that "With a 20% estimated precision . . ." which implies that random errors dominate and systematic errors are negligible. Is this really true taking into account that for plume enhancements relative to the background especially near-surface methane enhancements are relevant and the averaging kernels are close to zero near the surface (approx. 12%, see Fig. 3 bottom) and therefore the smoothing error is very important (see page 9, line 4: "The dominant sources of the total error are the smoothing error, . . ."). The smoothing error will correlate with the plume and will therefore be primarily a systematic error but not a random error, i.e., not part of "precision", with likely significant consequences if one wants to use the HyTES atmospheric methane retrievals to obtain quantitative emission estimates. These aspects need to be mentioned and described better in the manuscript to avoid misunderstandings.

There is a lack of citations of other relevant peer-reviewed publications. I recommend to add at least the following publications: Page 3, line 4 following: It is written that "Previous studies produced maps of methane distributions from airborne hyperspectral TIR sensor radiances using methods such as the Cluster-Tuned Matched Filter Detection (CMF) (Funk, 2001); however, such correlative approaches do not yield quantitative estimates of the methane plume concentrations or the corresponding methane emission rates. Our approach is based on . . .". Citing only Funk, 2001, is not sufficient as there are several more recent papers, which need to be considered in the discussion and cited in the manuscript. E.g., Tratt et al., "Airborne visualization and quantification of discrete methane sources in the environment", RSE, 2014, also needs to be cited (they also use TIR measurements and quantified their sensitivity in terms of methane emissions, which is not done in this manuscript). Furthermore, also airborne non-TIR methane measurements have been published (with averaging kernels close to unity at the surface) including detailed error analysis in terms of estimated methane emissions, e.g., Gerilowski et al., "Atmospheric Remote Sensing Constraints on direct Sea-Air Methane Flux from the 22/4b North Sea Massive Blowout Bubble Plume", Marine and

Petroleum Geology, 2015, and Krings et al., "Quantification of methane emission rates from coal mine ventilation shafts using airborne remote sensing data", Atmos. Meas. Tech., 2013. Furthermore I recommend to add on Page 2, line 24: Schneising et al., Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations, Earth's Future, 2014.

It is not clear where exactly which spectral information is coming from. I strongly recommend to add after Fig. 1 an additional figure based on radiance simulations showing how the radiance spectrum changes for a given perturbation of the key interfering parameters (methane, other gases, temperature, emissivity, . . .) (i.e., Jacobians) and how this compares with the (typical) noise level (please add info on how large each parameters is and by what amount it has been perturbed).

Page 9, line 4 following (see also above): "The dominant sources of the total error are the smoothing error, measurement error, atmospheric temperature error, H2O error, and emissivity error." Is "measurement error" just noise (if yes please add this in brackets; if not what systematic errors are relevant in addition to noise?). Which of these errors will likely be correlated with the plume and are therefore critical if one wants to get emission estimates. Please add at least a short discussion of this. In this context also page 10, top and middle: co-variations of parameters such as temperature and H2O are mentioned. Is the proposed chi-square filter (page 10, line 13 following) a solution that is supposed to eliminate these (potentially plume-correlated) error sources? I guess not, as Fig. 4 right does not show any data gaps in the plume. Please clarify.

Minor comments:

Page 2, line 3: "wide swath"? Please add how wide the swath is (e.g., for 1 km flight altitude).

Page 4, line 24: How are clouds modelled? In particular, where are the relevant parameters (altitude, optical properties) coming from to forward model the HyTES radiances?

Page 5, line 11 following: "In addition the issue of spectral band misregistrations is eliminated." This is a bold statement but it is unclear where it is coming from. Please add more details and a reference.

Page 7, middle, below Eq (6): "three terms"? I only see two terms? Please check and clarify/correct.

Page 8, line 18: 0.32 means 32% a priori uncertainty, or? Please clarify.

Fig. 4, right: Seems there are hardly any values below 2 ppm as "white are missing data" and the color bar starts at approx. 2 ppm but Fig. 5 shown there are data in the range 1-2 ppm. This is a bit misleading for Fig. 4 and I recommend to select a lower limit for the color bar (e.g., 1 ppm). I wonder why there are no data below 1 ppm in Fig. 5? Is this because they have been eliminated by a filtering procedure (I guess not but please clarify).

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